# COMPARATIVE EVALUATION OF THE EFFECT OF DIFFERENT BONDING AGENTS ON THE ULTRAMORPHOLOGY OF PRIMARY TOOTH DENTIN

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**The composition of dentin is different in primary and permanent teeth but the same bonding protocol has been advocated for both. Very few studies are available for primary teeth regarding the current bonding agents. The aim of the study was to analyse and compare the changes in the ultramorphology of dentin in primary teeth using different bonding agents.**

**18 extracted human deciduous teeth were collected. Occlusal surfaces of all the teeth were grounded to expose the dentin and were divided into four groups: (a) for viewing dentinal morphology (3 teeth), (b) with Scotchbond multipurpose (5 teeth), (c) with Adhe SE (5 teeth), (d) with Futurabond NR (5 teeth). The bonding agents were applied to each group following the manufacturer's instruction and samples were prepared for viewing under Scanning Electron Microscope.**

**Scotchbond Multipurpose was able to completely remove the smear layer from the dentinal surface. While the other two groups i.e Futurabond NR and Adhe SE were not able to completely remove the smear layer.**

**The etch and rinse approach helps in the complete removal of smear layer and opening of dentinal tubules. This may be responsible for better penetration of adhesive monomers.**

**Key words: Ultramorphology, Primary teeth dentin, SEM, Bonding agents.**

Over the past few decades, dentin bonding systems have become widely accepted for the clinical placement of resin composite restorations. Due to their inherent hydrophobic nature, composites are not able to maintain a good marginal integrity leading to microleakage, or the ingress of oral fluids and bacteria along the cavity walls which leads to failure of restorations and development of secondary caries. In order to preserve the tooth structure and maintain the restoration in the cavity, there should be adhesion between the restorative material and the tooth structure. Good adhesion has revolutionized the concept of cavity preparation and restorative procedures.[1]

Adhesion refers to the forces or energies between atoms or molecules at an interface that hold two phases together.[2] Adhesion to tooth substrate is based upon an exchange process by which inorganic tooth material is exchanged for synthetic resins.[3,4] There are three basic steps in adhesion- etching, priming and bonding.

The advent of bonding dates back to 1955 when Michael G Buonocore used 85 per cent phosphoric acid solution to etch human enamel and found an increase in adhesion of acrylic to enamel.[5] There has been a trend to move from the original type of multicomponent bonding system towards simplified, consolidated adhesive systems that are more user- friendly.[6] The complexity and the number of steps involved with the fourth generation system led the researchers to develop simpler adhesive systems.[7]

Previous studies have shown that there is difference in dentinal composition and morphology between primary and permanent teeth.[8] Concentrations of calcium and phosphorus in both peritubular and

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intertubular dentin are lower in primary teeth. The interface formed in primary teeth is thicker and there is incomplete impregnation of bonding system in the collagen network, resulting in reduced adhesive strength.[9]

There is deficiency of literature reporting the action of the current bonding agents on dentin of primary teeth. Taking into account that the information about the use of the latest generation of bonding systems for primary teeth is limited,[8] the aim of the study was to analyse and compare the changes in the ultramorphology of dentin in primary teeth using different bonding agents.

**Materials and Method**

18 extracted human deciduous teeth were collected. Occlusal surfaces of all the teeth were grounded with water cooled air turbine using diamond burs (Shofu Inc, Kyoto, Japan) and were abraded with 600 grit abrasive paper to expose the dentin. After exposing the dentin the teeth were mounted in acrylic resin with flat dentinal surface facing upwards. They were divided into following four groups:

- Group A: For dentinal morphology (3 tooth)
- Group B: with Scotchbond multipurpose (5 teeth)
- Group C: with Adhe SE (5 teeth)
- Group D: with Futurabond NR (5 teeth)

The bonding agents were applied according to manufacturer's instructions.

The specimens were rinsed with distilled water. All the samples were then sequentially dehydrated in ascending grades of ethanol i.e 60% ,70%, 80%, 90% alcohol for 20 min each and in 100% alcohol for 1hr.

All samples were dried, mounted on aluminium stubs which were then placed in vaccum chamber and sputter coated with gold layer and were observed under a scanning electron microscope.

Series of photographs were taken field by field at a magnification of 2000x and 10000x for viewing the surface morphology.

**Observations and Results**

Analysis of the specimens in cross- sections

| S. No | Name | Composition | No. of steps |
|---|---|---|---|
| 1. | Scotchbond Multipurpose | Etch: 35% Phosphoric acid | Three |
| | | Primer: Water, HEMA, polycarboxylic acid copolymer<br>Adhesive: BIS-GMA, HEMA, CQ, EDMAB, DHEPT | |
| 2. | Adhe SE | Primer: Phosphoric acid acrylate, Bis-acrylamide, water, initiators, stabilizers<br>Adhesive: Dimethacrylates, hydro-ethil methacrlate, highly dispersed silicon dioxide, initiators, stbilizers | Two |
| 3. | Futurabond NR | Liquid A: Polyfunctional adhesive monomers, dimethacrylates, functionalized Sio2 nano- particles, initiators<br>Liquid B: Ethanol, water, hydrophilic adhesive monomers, fluorides | One |



*Fig. 1: (a) SEM photomicrograph illustrating the smear layer-covered dentin. (2000x), (b) SEM photomicrograph illustrating the smear layer-covered dentin.(10000x)*



*Fig.2: (a) SEM photograph illustrating a cross-section of the dentin surface after treatment with Scotchbond Multipurpose (2000x), (b) SEM photograph illustrating a cross-section of the dentin surface after treatment with Scotchbond Multipurpose (10000x)*

showed a varied morphology that depended on the various dentin pre- treatments.

**Group A (no treatment):** the smear layer covered dentin observed in cross- section showed a surface completely covered by a crust of cutting debris that appeared to have little surface porosity. The orifices of the underlying tubules were completely obstructed by grinding debris. [Fig. 1]

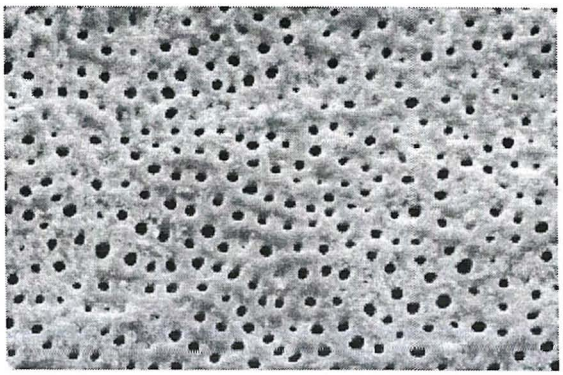


*Fig.3: (a) SEM photograph illustrating a cross-section of the dentin surface after treatment with Adhe SE (2000x), (b) SEM photograph illustrating a cross-section of the dentin surface after treatment with Adhe SE (10000x)*

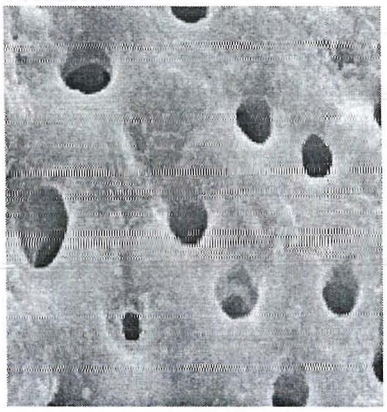


*Fig.4: (a) SEM photograph illustrating a cross-section of the dentin surface after treatment with Futurabond NR (2000x), (b) SEM photograph illustrating a cross-section of the dentin surface after treatment with Futurabond NR (10000x)*

**Group B (Scotchbond Multipurpose):** treatment with Phosphoric acid resulted in a demineralized layer that appeared to have collapsed in its outer most part. The smear layer was completely removed and the dentinal tubules opened. A higher magnification image focus showed some remnants of smear layer. [Fig. 2]

**Group C (Adhe SE):** the self- etch primer was not sufficient to remove the smear layer and open the dentinal tubules. Remnants of smear layer could be seen on the surface of dentin plugging the tubules. [Fig. 3]

**Group D (Futurabond NR):** showed that treatment with this group was strong enough to dissolve the smear plugs. The demineralization was superficial and did not show noticeable difference between the intertubular or peritubular dentin collar around the lumen of the tubules. [Fig.4]

## Discussion

The fundamental principle of adhesion to tooth substrate is based upon an exchange process by which inorganic tooth material is exchanged for synthetic resin.[3,4] This process involves two phases. One phase consists of removing calcium phosphates by which microporosities are exposed at both enamel and dentin tooth surface. The other so called hybridization phase involves infiltration and subsequent in situ polymerization of resin within the created microporosities.[1]

The original bonding agents evolved from simple to multistep systems, whereas recent developments have focused on simplification. Out of all generations, fourth generation or the three step bonding agents have been the most successful.

Because of the complexity and number of steps involved, manufacturers worked to develop simpler adhesive systems in the form of fifth, sixth, seventh and eighth generation adhesives. These bonding agents either consist of a single component or two components which are mixed together before application, thus reducing the number of steps.[7]

Bonding to enamel has been considered a reliable procedure due to its uniform composition (hydroxyapatite) but bonding to dentin remains a challenge, as it contains higher water content and more organic material, mainly type I collagen.[10,11] Dentin is an intrinsically wet tissue penetrated by a tubular network that communicated tissue fluids of the pulp chamber.[11,12] Furthermore, when cutting procedures are performed on tooth structure, the dentin surface becomes covered with a 1μm thick layer of debris composed mostly of submicron particles of mineralized collagen matrix.[11,13]

Primary dentin has been assumed to be different from permanent dentin due to the variable amounts of mineral components, as well as morphological and structural differences. The interface formed in primary teeth is thicker and there is incomplete impregnation of bonding system in the collagen network, resulting in reduced adhesive strength.[14]

Senawongse P et al evaluated the bond strength of a total etching, self- priming system and a self-etching system to deciduous and permanent human dentin and found that no significant differences were seen between the materials. The deciduous dentin however demonstrated significantly lower bond strength than permanent dentin.[15]

In the present study we compared the action of different generations of bonding agents on primary teeth, so that their beneficial results could be compared. Shorter application time and lesser number of applications may prove helpful in pediatric patients.

A prerequisite for bonding is the close approach of bonding agent and substrate. Thus the inherent wetness of the dentin tends to cause a problem.[16,17] Unless the bonding agent displaces or is miscible in the fluid in areas where the dentin is most permeable, it will be difficult to achieve a stable long lasting bond.[16,18] There are two different ways that the current bonding systems obtain acceptable micromechanical retention between resin and dentin. The first method is based on complete removal of the smear layer and demineralization of subsurface intact dentin.[10,11] The second method uses slightly acidic monomers, the so-called self- etching primers, to partially demineralize the smear layer remnants and using them as a bonding substrate.[11,19]

The results of our study showed the presence of

smear layer in cross- sections as compact crust. Thus the only two options available include removal of the smear layer or application of such agents that can penetrate the smear layer into the underlying dentin matrix.

When the acidic conditioners remove the solid mineral content of the smear layer, the residual collagen phase of the smear layer persists, thereby enriching the surface with organic material that may then partially occlude the spaces between demineralized collagen fibers, interfering with adhesive infiltration.[11,13]

Van Meerbeek et al reported that when acid is applied to dentin, mineral component is removed exposing the collagen network.[20,21]

The application of total etch and self- etch systems in the present study have shown differences in the surface morphology of the dentin. With Scotchbond Multipurpose, the dentinal tubules open up completely with only a few remnants of smear layer, while in case of the self- etch primers the dentinal tubules do not open up completely in case of Futurabond NR, while no open dentinal tubule were seen with Adhe SE. This can affect the penetration of low viscosity monomers into microporosities created, which are invariably responsible for higher bond strength.

These findings were supported by Courson F, who found that the bond strength of Scotch bond multipurpose was higher than the other two- step or single- step bonding agents in primary and permanent teeth.[22]

When using dentin bonding agents, the smear layer over the intertubular dentin must be removed, opening the dentinal tubules for the formation of hybrid layer, which is ultimately responsible for strong and stable adhesion of composite resin to dentin.[21,23,24] The characteristics of acidic monomers determine the ability of self-etch adhesives to etch enamel and dentin. The self- etching primers have acidic monomers in their composition with higher pH values compared to traditional acids used. Thus they cause lesser degree of demineralization of the dental substrate.[8,25]

So far, no study has been published that describes either the effect of Futurabond NR or Adhe SE on the ultramorphology of deciduous teeth. The action of Futurabond NR in opening the dentinal tubules and removal of smear layer could be due to the lower pH (1.4); the pH of Adhe SE is slightly higher (1.7). Gregoire G stated that pH alone, cannot explain the differences in action. Demineralization depends on several factors namely pH, the dissociation constant (pKa), the structure of the compounds, which may be more or less chelating, solubility of the salts formed and the application time. Action depends on the acid monomers and their concentration.[26]

The results of our study showed that the additional step of etching and rinsing in three step bonding agents, helps in the complete removal of smear layer and better penetration of the adhesive, which may be further responsible for better bond strength. But precautions have to be taken to prevent collapsing of the collagen fibers. Erickson et al also supported the above finding and stated that though strong acids remove the smear layer and smear plug completely; they cause excessive demineralization of intertubular and peritubular dentin, which is detrimental for the bond strength.[21,27]

Since very few studies are available on the effect of different bonding agents on primary teeth so this study can be an useful additional. However, more research is required in the field of adhesive dentistry to develop such a bonding agent which combines the mechanical properties of fourth generation bonding agents, requires fewer number of application steps, thus obtaining the best retention and saving on time.

**Conclusion**

After preparation of dentinal surface with dental instruments it is seen to be covered with a layer of smear layer.

1. Three- step bonding agent results in the complete removal of smear layer. While the self-etch approach is not efficient in removing the smear layer and opening of the dentinal tubules.
2. The opening of dentinal tubules and better penetration of low viscosity monomers may be responsible for the greater shear bond strength seen in case of etch and rinse approach.

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